Bridge Design and Construction at Reiseter Creek near Smithers, B.C.

Complaint Investigation 010358

FPB/IRC/86

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The Investigation

This complaint investigation concerns a bridge built by West Fraser Mills Ltd. (the licensee) across a tributary of Reiseter Creek, 20 kilometres northwest of Smithers. A local resident (the complainant) complained to the Forest Practices Board (the Board) in December 2001 that:

1. The licensee designed and constructed the bridge in contravention of the *Forest Practices Code of British Columbia Act* and its regulations (the Code), causing the bridge to fail and possibly damage the creek; and

2. The Ministry of Forests (MOF) did not adequately enforce Code provisions dealing with roads and bridges.

Background

Reiseter Creek is a small fish-bearing tributary to the Bulkley River. Resource management in the area is guided by the *Bulkley Land and Resource Management Plan* (LRMP). The LRMP designates resource management zones according to intensity of resource use. It designates some of the area around Reiseter Creek as a special management zone, where development must proceed within the primary constraints of protecting water quality and visual quality. The Community Resources Board (CRB) led the development of the LRMP and provided consensus guidelines for managing the Reiseter Creek special management zone. The consensus guidelines for that zone include building roads in a way that minimizes impact on water quality, and using "best management practices" for erosion and sediment control. Neither the LRMP nor the consensus guidelines define best management practices.

The licensee has a forest licence for an operating area around Reiseter Creek, and intended to access timber east and south of Reiseter Creek using a five-kilometre road extension from the south. The intended route was disallowed by the LRMP, which designated the area of the route as part of a protected area. The licensee then considered several options for accessing the area from the west, and selected a preferred road and creek crossing based on the existing terrain conditions and projected constructions costs. The preferred route required over 15 kilometres of road and more stream crossings than the original southern route. The crossing was located just outside of the Reiseter Creek special management zone. The licensee laid out the road to the creek crossing in 2000 and hired a geotechnical engineer (the terrain assessor) to complete a terrain stability field assessment (TSFA) to provide an on-site assessment of the potential impact of road construction on terrain stability. The licensee hired another engineer (the bridge designer) to design the bridge. The design showed a seven metre-high fill for one of the approaches to the bridge.

The MOF district manager approved a permit for the road in October 2000. The licensee built the road to the crossing site in October 2000, and started building the bridge soon after. In December, after placing part of the approach fill, a foundation failure occurred and the fill and surrounding ground slumped downslope. This type of ground movement is called a rotational slump, and in this case it caused a narrow tension crack running for 30 metres. The slump shifted the bridge support piles, but did not result in the bridge span collapsing.

The licensee hired another engineer (the remediation engineer) to assess the site at the crossing and to determine an action plan for the completion of the project. The remediation engineer's opinion is that loading the fill on clay sediment initiated the instability. The licensee implemented the remediation engineer's recommendations to support and stabilize the area.

In March 2001, the CRB asked the district manager whether the licensee should have assessed stability at the crossing site with sub-surface drilling prior to building the bridge. In response, MOF asked its regional roads engineer to determine whether the licensee had followed best management practices as per the CRB's consensus guidelines. The MOF engineer concluded that, without a definition of best management practices, he could not assess whether the licensee had used best management practices but could only assess for Code compliance. He stated that, in the context of water quality, "best management practices" would probably require overriding care in the development process. MOF then investigated whether Code contraventions occurred. MOF compliance and enforcement staff concluded that the licensee had complied with the Code, so the district manager did not levy any penalties.

The complainant asked the Board to investigate whether the slump damaged the environment. The complainant believes that the licensee did not use best management practices and that the district manager did not adequately enforce the Code. The complainant wants to ensure that future development in the special management zone follows the LRMP and the Code. He therefore requested that the Board independently review the slump.

The licensee has built a redesigned bridge at the crossing site, with a lengthened span and a smaller approach fill. The licensee is monitoring sub-surface conditions, and has not yet placed the entire approach fill.

Issues Investigated

The Board addressed the issues of the complaint by considering:

1. Did the slump damage the environment?
2. Did the licensee use best management practices?
3. Did the licensee meet the requirements of the Code?
4. Did the Ministry of Forests adequately enforce the Code?

Did the slump damage the environment?

The Board heard from the regional engineer, MOF and the Department of Fisheries and Oceans (DFO) that soil from the slump or approach fill did not reach the creek and affect water quality or result in environmental damage, and the Board accepts these opinions. The Board notes that the licensee's work within the riparian reserve zone to support the unstable area was done with the consultation and support of DFO, the Ministry of Environment, Lands and Parks (MELP, now the Ministry for Water, Land and Air Protection) and MOF. While it is possible that the slump could continue moving, the licensee has undertaken measures to reduce the risk of any subsequent environmental damage. This includes hiring the remediation engineer to develop an action plan, installing a rock berm in front of the pier piles, installing instruments to measure subsurface conditions, and redesigning the bridge.

Did the licensee use best management practices?

The CRB's consensus guidelines for managing the Reiseter Creek special management zone are referenced in the licensee's approved forest development plan. By incorporating these requirements in its forest development plan, the licensee has set an additional level of Code obligations for its operations. The consensus guideline includes the following excerpts, which the Board interprets as applying to road and bridge development: "Within the SMZ (special management zone), roads are to be built with minimum impact on water quality; best management practices are to be used for erosion and sediment control; road rights-of-way and running surfaces should be as narrow as possible."

The consensus guidelines do not provide measurable criteria defining best management practices. The Board was therefore unable to assess whether best management practices were used. The Board notes that the licensee, in keeping with its commitments to follow best management practices, used digital terrain models to assess visual quality impacts for the proposed Reiseter Creek access road, and is monitoring water quality in Reiseter Creek in co-operation with ministries.

Did the licensee meet the requirements of the Code?

1. Assessments for a road layout and design

A person completing a road layout and design must follow procedures set out in the Code, including the following assessments:

- A licensee must select stream crossings so that channel and bank disturbances can be prevented or mitigated, and any bridge or culvert will be stable [section 4 of the *Forest Road Regulation* (FRR)].

- A licensee, prior to building the road, must complete a TSFA wherever terrain stability hazard maps show a moderate-to-high likelihood of landslides (section 4(5) of the FRR). If the road will cross areas determined by the TSFA to

have a moderate or high likelihood of landslides, a qualified professional must verify that the road design includes measures to maintain slope stability in those areas (section 8 of the FRR).

- A TSFA must be carried out in accordance with procedures set out in the *Mapping and Assessing Terrain Stability Guidebook, 2nd ed., 1999* (section 1 of the FRR).

The Code requires that the TSFA follow a designated procedure; it does not provide specific requirements for the quality or the accuracy of the TSFA. The Board considers the adequacy of the TSFA later in this report. With regard to the procedure; the Board finds that the TSFA varied from the *Mapping and Assessing Terrain Stability Guidebook, 2nd ed., 1999* guidebook (the guidebook) procedures, but was consistent with the discretion provided by the guidebook. Therefore, the Board finds that the road layout and design was completed in accordance with the procedures set out in the Code for selecting a stream crossing and completing a TSFA.

2. Bridge design

Bridges over 12-metres long must be designed by a professional engineer (section 10(1) of the FRR). Section 10(2) of the FRR further states that bridges must be designed in accordance with the requirements of the Canadian Standards Association and the *Canadian Foundation Engineering Manual* (the CFE manual).

The CFE manual provides expert advice for undertaking site investigations to appraise foundation conditions. Site investigation includes analyzing information gained through geological surveys, sub-surface drilling, visual inspections and local experience. It emphasizes the importance of collecting previous information, stating:

> Site investigations should be organized to obtain all possible information commensurate with project objectives for a thorough understanding of the subsurface conditions and probable foundation behaviour; and
>
> Before the actual field investigation is started, information should, whenever possible, be collected on: ...the probable soil conditions at the site by analysis of geological and geotechnical reports and maps, aerial photographs, and satellite photographs.

The CFE manual also provides guidance on the extent of the ground investigation, which means examining sub-surface conditions through methods such as drilling or examining soil profiles exposed through cut banks or old landslides:

> The extent of the ground investigation is determined by the soil type and variability of soil and groundwater, the type of project, and amount of existing information...The greater the natural variability of the ground, the greater will be the extent of the ground investigation required to obtain an indication of the character of the ground.... More detailed information should be obtained at the

location of important structures and foundations, at locations of special engineering difficulty or importance and where ground conditions are complicated, such as suspected buried valleys and old landslide areas.

MOF's design and construction manual provides policy guidance about what might be considered an important structure requiring more extensive ground investigation. It states that geotechnical studies must be performed by specialists for all bridges costing more than $250,000 and for other individual bridges where MOF considers it necessary.

The Board examined the Code-referenced CFE manual and finds that the bridge designer has discretion to vary from the guidance of the CFE manual. The Board finds that the bridge design varied from the manual's guidance for site investigation, but that was consistent with the discretion provided by the manual. The Board finds that the bridge design was completed in accordance with the procedures set out in the Code for bridge design. The investigation considers later whether the site investigation was adequate for the circumstances.

3. Forest practices

When carrying out an approved forest practice, such as building a road and bridge, results in any slumping or sliding of land, it triggers section 45(3) of the *Forest Practices Code of British Columbia Act*. Section 45(3) states that a person must not carry out a forest practice if he or she knows, or should reasonably know, that, due to site factors, carrying out the forest practice may result–directly or indirectly–in slumping or sliding of land. A person who contravenes that section must stop the forest practice, prevent any further damage to the environment, promptly notify the MOF district manager and take any remedial measures that the district manager requires (section 45(4) of the Act). The person may resume the forest practice if it can be resumed without contravening section 45(3), and any remedial actions required under section 45(4) have been carried out to the satisfaction of the district manager.

Through terrain mapping, the TSFA and field visits, the licensee assessed whether building the crossing would cause slumping or sliding of land. Those sources provided information indicating that the crossing site was potentially unstable. Terrain mapping indicates that the Reiseter Creek area is sensitive to disturbance, and rates the terrain hazard for the crossing area as Class V, meaning that the area is expected to contain areas with a moderate likelihood of landslide initiation following timber harvesting or road construction. It shows the area of the crossing as a landslide initiation zone. The TSFA identifies nearby unstable areas that fall within the area described by terrain mapping as a landslide initiation zone. The TSFA reports that there is a bedrock failure on the town side that terminates within the creek. Furthermore, the area of the crossing has "imperfect to poor drainage" in association with silty soils. The heavy, seven-metre approach fill on top of these potentially unstable ground conditions could further increase instability.

Given the presence of the landslide initiation zone, instability concerns identified in the TSFA and terrain mapping, and the loading of the seven-metre fill, the licensee arguably should have been aware that the crossing location was potentially unstable. However, the licensee's engineer, the bridge designer and the terrain assessor did not see any obvious signs of active instability at the immediate crossing site during field visits. The terrain assessor rated the likelihood of road construction initiating a landslide to be low for the crossing site. The licensee had reason to conclude that constructing the crossing would not result in land slumping or sliding. The Board therefore finds that the licensee met the requirements of section 45(3) of the Act. The Board also considers that the licensee's response to the failure fully met the requirements of section 45(4) and 45(5) of the Act.

Did the Ministry of Forests adequately enforce the Code?

The purpose of enforcement is to promote compliance with the Code and, in the Board's opinion, to ultimately promote learning and improve forest practices. Field inspections and monitoring are the most common activities in the ministry's enforcement program. These should be done at a frequency that is appropriate for the risk that exists to the resource. If problems are discovered, there are a number of tools available to the ministries to promote compliance. These tools escalate in severity and include written instructions, stop-work orders, administrative penalties, prosecution and licence cancellation.

In this case, the district prepared a risk assessment at the time of project approval and determined a low risk for the crossing, resulting in a low inspection priority. After the failure, the district requested that the regional roads engineer review all professional assessments, designs and practices relevant to the slump, and consider whether the assessments and designs provided a reasonable assessment of risk. The district discussed the results of the regional engineer's report with the licensee, the bridge designer and the terrain assessor. MOF also investigated whether the licensee followed the Code's requirements for terrain stability assessments, road layout and design, and the forest practices requirement of section 45(3) of the Act.

The Board accepts the results of MOF's compliance and enforcement investigation. The regional engineer's review and the district's compliance and enforcement investigation together provided a comprehensive analysis of the slump event. In particular, the regional engineer's report identified issues about the adequacy of the TSFA, the licensee's coordination of professional work, and the Code's lack of clarity regarding responsibilities for terrain assessors, road designers and bridge designers. By analyzing unexpected outcomes (such as the slumping and resulting displacement of the bridge), it should be possible to avoid those same outcomes in the future. However, the district did not follow up to ensure that issues identified in the regional report were addressed. Instead, MOF's enforcement actions concluded with an investigation of whether process was followed. An enforcement program that simply assesses whether process was followed, without asking whether it was followed appropriately, cannot provide the analysis and feedback necessary to fully understand why an unexpected outcome occurred.

Other Issues

The Code is not intended to fully eliminate the risk associated with a forest practice. The Board recognizes that any forest practice on the land involves some risk. The Board believes that risks should be fully identified and understood at each stage of a project, so that informed resource decisions can be made. For the Reiseter Creek crossing, the Board identified risk issues related to field assessments and designs, project proposal and project approval stages. Those issues are discussed here, in keeping with the Board's fundamental purpose of encouraging sound forest practices.

Field Assessments and Designs

Licensees and ministries often assess risk of a forest practice based, in part, on the results of professional assessments and designs. Professionals provide expertise that a licensee and ministry often lack. In this case, professionals completed a TSFA, designed a bridge, and signed off a portion of the road layout and design. That professional work was consistent with the Code procedure, yet a slump occurred during the construction phase of the project. In analyzing this case, the Board identified three issues:

1) Gaps in the Code

2) The scope and limitations of professional assessments

3) The adequacy of professional assessments

1) Gaps in the Code

The Code is not explicit about whether an approach fill should be considered in a TSFA, road design or bridge design.

The Code, CFE manual and MOF's bridge construction manual do not require a bridge design to consider an approach fill. That is because an approach fill may not have much impact on a bridge structure, depending on the bridge design and terrain conditions. The Code and terrain stability guidebook do not require a TSFA to consider an approach fill. TSFAs are intended to rate the likelihood of landslides resulting from conventional cut and fill road construction, not from the placement of a heavy approach fill. Further, TSFAs are typically completed prior to road layout and bridge design, so a terrain assessor would likely not know the amount of fill at the time of the assessment.

An approach fill is part of the road prism and, as such, is a component of the road layout and design under the Code. Where an approach fill falls in an area determined by a TSFA to have a moderate-to-high likelihood of landslides, a professional must ensure that portion of the road layout and design includes measures to maintain slope stability. Where a TSFA rates the likelihood of landslides as low, as occurred in this case, nobody has clear responsibility for approach fills.

The Code's lack of clarity about approach fills contributed to the TSFA, bridge design and road design not addressing the risk associated with the heavy approach fill. However, legislation is not intended to foresee and address every possible circumstance. Rather, the Code provides discretion to allow flexibility to address individual circumstances. The Code provides discretion for assessment and design procedures, and for reviewing and approving them. That places responsibility back on the professionals, licensees and ministries for identifying and addressing risk associated with a project.

2) Scope and limitations of professional assessments

The discretion provided by the Code increases the need for professional assessments and designs to clearly describe methodology, scope limitations, and implications of scope limitations in order for a licensee and ministries to understand a project's risk. The methodology of the Code-referenced guidebooks and manuals represent the knowledge of the day supported by the best available scientific information, and expert experience and advice. If deviating from the accepted standard guidebook or manual procedures, the professional takes on risk and must assume the responsibility for that added risk–or make that risk apparent to the licensee. In this case, the TSFA states that aerial photos were not reviewed, but does not explain how that might impact the results contained within the report.

Both the road design and TSFA had scope limitations. One scope limitation is that the bridge design did not consider subsurface investigation. The design clearly states that limitation, but does not outline the risk associated with constructing the crossing without undertaking subsurface investigation.

Another scope limitation is that the terrain assessor and the bridge designer both considered the approach fill to fall outside their terms of reference. However, the TSFA and the bridge design do not state anything to that effect. Instead, the bridge design references "compacted granular backfill" and shows a barrier on top of the fill. The TSFA states, "the grade of the bridge will be built up using fills and appropriate measures." The TSFA and the bridge design both create the impression that the approach fill was considered, although it was not. The TSFA and the bridge design do not state their scope limitations regarding the heavy approach fill and are not clear about whether they address the risk associated with the fill.

In summary, the Board finds that the bridge design and TSFA did not clearly describe variance from recommended procedure, scope limitations, or the implications of scope limitations. Consequently, the bridge design and TSFA make it difficult for the licensee and MOF to understand the risk associated with the project.

3) The adequacy of professional work

The terrain stability field assessment

Professional risk assessments must accurately describe risk for a licensee to be able to evaluate a project. In this case, the terrain assessor determined the likelihood of landslides to

be low, based on field observations for the immediate right-of-way of the road and crossing, and a low-level overview flight. The Board did not determine whether the low rating is accurate, as that would require an additional field assessment by a qualified professional. However, the Board considered the TSFA result relative to other available information.

The mapping and assessing terrain stability guidebook outlines the importance of reviewing and assessing relevant available information when undertaking TSFAs. Aerial photos and the results of the 1998 terrain mapping report were available for the Reiseter TSFA. The terrain mapping report provides landscape-level information at a scale of 1:20,000 describing the surficial geology and potential instability of the area. The report presents an assessment of terrain stability with a high degree of confidence, stating that the reliability of the terrain mapping is considered very good and that map polygons are expected to reliably describe on-ground conditions. It flags potential concerns for further consideration, stating that decisions on logging or road construction should be based on detailed field evaluation.

Terrain mapping indicates the sensitivity of the general Reiseter Creek area. For the specific terrain map unit that includes the area of the crossing, it rates the terrain hazard as Class V (unstable). That area corresponds with an old rotational landslide feature (now forested) that is visible in the aerial photos, when viewed through a stereoscope to provide a three-dimensional view. The photos show that the area upslope of the bridge is a landslide initiation zone, and that the road and bridge approaches are located at the toe of this historical feature. Numerous smaller landslide features occur within the terrain map unit.

The Code intends terrain mapping to guide where and when a more detailed on-site TSFA should be carried out. Forest management decisions are to be based on the on-site assessments provided by a TSFA, rather than on the more general information provided by terrain mapping. The terrain assessor concluded that the likelihood of landslides was low, based primarily on observations within the immediate road right-of-way, where there were no indicators of active instability. However, the TSFA report does not explain the discrepancy between its low rating and the Class V rating of the terrain mapping, despite the confidence with which the terrain mapping results are presented. The TSFA does not recognize the old rotational landslide, as it was not apparent during the flyover. The report did not adequately consider the crossing in the context of the broader terrain unit that exhibited numerous signs of instability. The Board finds that the TSFA report did not adequately justify the low hazard rating, given the terrain-stability issues that are evident at the landscape level or through a review of the other available information.

The bridge design

Bridge designs for forest roads are typically completed without any subsurface analysis. In this case, the bridge design engineer designed the bridge without a subsurface assessment, relying heavily on the TSFA report, lack of active instability indicators in the road corridor, and an overall bridge cost of less than $250,000. With a low likelihood of landslide rating, no visible instability indicators, and MOF policy which required more extensive ground

investigation when a bridge costs more than $250,000, the bridge designer followed customary practice by designing the bridge without subsurface investigation.

In the Board's opinion, the cost of a bridge is not a good measure of environmental risk. Further, the *Canadian Foundation Engineering Manual* should take precedence over MOF policy, since the manual is referenced in the Code. As already discussed, the *Canadian Foundation Engineering Manual* provides a range of considerations for determining the extent of ground investigation.

The terrain mapping report, the TSFA report and road design included information relevant to the need for ground investigation:

- complex soil stratiography including deep glacio-lacustrine soils
- imperfect to poor drainage
- indicators of instability along Reiseter Creek
- class V terrain stability rating, indicating the area is expected to contain areas with a high likelihood of landslide initiation following timber harvesting or road construction
- evidence that the crossing site is on an old rotational landslide
- bedrock failure at the crossing site that terminates within the creek
- planned use of a heavy approach fill

The Board interprets that, given the advice of the Code-referenced CFE manual, the sum of those conditions should have triggered consideration of a more detailed ground investigation. The Board finds that the bridge design did not adequately justify the decision to not undertake a more detailed site investigation.

Project Proposals

Licensees are responsible under the Code for work done as a result of professional assessments. A licensee should therefore ensure that professional work is adequately reviewed and coordinated to identify any gaps or contradictions in the professional work.

The licensee's expectation was that the TSFA, bridge design and road design would identify and address any instability risks associated with the crossing. However, the licensee contracted out work on a piecemeal basis, with none of the consultants responsible for the overall road and crossing system. The piecemeal approach placed responsibility back on the licensee for overseeing the overall project. The licensee's review and coordination of the professional assessments was inadequate to identify the gaps or contradictions in professional work. Therefore, the Board believes that the licensee did not fully understand the risk associated with building the crossing.

Project Approvals

The district's policy, when reviewing work for approval under the Code, is not to review professional assessments in any detail. Instead, MOF relies on the professionals and/or the companies responsible for the work. While the Board generally supports this approach, MOF's review of the project did not identify the gaps and contradictions in professional work and, therefore, did not adequately consider the risk associated with approving this project.

In discussing the preceding issues of risk, the Board identified a number of opportunities for improvement. To fully identify, understand and manage the risk associated with the project, the following was needed:

- A more thorough consideration of the potential effect of the approach fill during the preparation, review and approval of the road and bridge designs.
- Clearer descriptions, in the work prepared by professionals, of variances from recommended procedures, scope limitations and implications, and linkages to other professional work.
- A more thorough review and consideration of the available information describing terrain conditions.
- Better review and coordination of professional work to identify gaps, limitations and contradictions of the work.

Conclusions

The creation of a protected area through the LRMP process resulted in the licensee accessing timber using a less favourable route from the west that included crossing a tributary of Reiseter Creek. The slump that occurred during the construction of the crossing did not damage the environment. The licensee acted promptly to limit the risk of any subsequent damage.

The road design and bridge design met the process requirements of the Code. The Ministry of Forests adequately enforced the process of the Code, but did not follow through on its enforcement actions to promote learning and improve forest practices.

The bridge designer, terrain assessor, licensee, and MOF all shared accountability for identifying and addressing the risk associated with the crossing. The Board finds that the risk of the project was not fully identified and understood.

Commentary

The Board understands that government's model for a results-based code proposes to shift responsibility and accountability to the licensee for ensuring sound, sustainable forest management. Licensees will be responsible for managing risk and deciding whether assessments are necessary before carrying out a forest practice. Where a licensee decides that more than one assessment is necessary, the licensee will need to clearly outline the parameters for each assessment to ensure all risks are identified. In support of sound forest practices, professional associations will need to determine and clearly define the responsibilities for assessments conducted by their members. MOF will remain responsible for overseeing the management of the public's forest resources, and therefore needs to adequately review the risks associated with a forest practice before giving it approval.

Recommendations

In accordance with section 185 of the *Forest Practices Code of British Columbia Act*, the Board makes the following recommendations:

1. Professional assessments should be done in a way that allows a licensee to understand the risk associated with a project. An assessment should clearly explain how it relates to other assessments, what the results mean, how the results were determined, any variances from recommended procedures, the scope limitations of the assessment and the implications of those limitations. Recommendations to address the identified limitation(s) should be provided by the professional.

2. The Board recommends that MOF's compliance and enforcement program follow through on its investigations to ensure that learning occurs from unexpected outcomes such as the Reiseter Creek crossing. Such learning should be shared to help improve forest practices.